GINA CODY
SCHOOL OF ENGINEERING
AND COMPUTER SCIENCE

# MECH 451
# Renewable Energy: Fundamentals and Applications

Winter 2025

**Course Instructor**: Dr. Lyes Kadem, ing
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**Office Hours**: Tuesdays and Thursdays 4:00 – 5:00 pm

**Lectures:**

| | | | | |
|---|---|---|---|---|
| | Renewable Energy: Fundamentals (Lecture) | 29 | Mo 11:45AM - 2:30PM | LS 207 SGW |

**Tutorials**:
N/A
**Labs:**
N/A

**Course Calendar Description**:
This course introduces the fundamental aspects and the main applications of renewable energy systems. The focus is on the thermodynamics, heat transfer and fluid mechanics aspects of renewable energy systems. The course covers the following topics: review of thermodynamics, review of heat transfer, review of fluid mechanics, solar energy, wind energy, hydropower, geothermal energy, biomass energy, ocean energy and hydrogen and fuel cells. Lecture three hours per week.

**Prerequisites**:
MECH 351 (Thermodynamic II)
MECH 352 (Heat Transfer I)
MECH 361 (Fluid Mechanics II)

**Specific Knowledge and Skills Needed for this Course:**
This course requires a very good knowledge in:

- Thermodynamics
- Heat Transfer
- Fluid mechanics

The material covering Heat Transfer is also available on MIAE 101 Moodle page.
The knowledge base for engineering required for this course will be covered during the first lecture and tested during Quiz 1.

**Course materials**
Note: There is no mandatory textbook. A course pack and a problem pack can be freely downloaded from the course website: https://users.encs.concordia.ca/~kadem/teaching/mech451/

All course notes are available on the course website and on Moodle.

**Recommended textbook:**

- "Fundamentals and Applications of Renewable Energy" by Kanoglu, Cengel and Cimbala, any edition with SI units, McGraw-Hill.

**Grading**

| **Evaluation Tool** | **Weight** |
|---|---|
| Quiz (basic knowledge of Thermal Science) | 7% |
| Test#1 (Tentatively: March 10th) | 45% |
| Test #2 (scheduled by the exams office) | 45% |
| Design portfolio | 3% |
| **Total** | **100%** |

**Passing Criteria:**

- *ALL exams are mandatory, and ALL exams will be counted.*
- *Any missing quiz or test for a valid reason approved by the course instructor will be replaced by an oral theoretical examination (not necessarily covering the same topics as the quiz or the midterm).*
- *Design portfolio: The objective here is to encourage you to create an online design portfolio where you will be posting your design achievements. This will be a very interesting added value when you will be applying for jobs or internships. In Thermo II, I will be asking you to post the report for the energy project as well as the material regarding your design for the steam car competition. I also encourage you to add your designs for MECH390 and MECH 490. You can use any online free webpage service to create your portfolio (exp: jimdo, weebly ,..). You will be submitting the link to your design portfolio on Moodle to get a bonus up to 3%.*

**Lab Details**

N/A

**Engineering Tools**

Open Source Software:

- Solar PV, Solar Thermal, Wind, Biomass, & Hydropower – *RETScreen*
- Geothermal energy - *HyGCHP Modeling Tool*
- Ocean energy - *DTOcean suite*
- Hydrogen and fuel cells - *H2FillS: Hydrogen Filling Simulation*
- *DWSIM*
- *Ashes*

**Syllabus:**

1) Introduction of Renewable Energy and Review of Thermal Sciences
2) Wind Energy
3) Ocean Energy

4) Hydro Power
5) Hydrogen and Fuel Cells
6) Fundamentals of Solar Energy
7) Solar Energy Applications
8) Geothermal Energy
9) Biomass Energy
10) Economics of Renewable Energy

**Graduate Attributes**:
The following is the list of graduate attributes (skills) that students use, learn and/or apply throughout the term.

| ATTRIBUTE | INDICATOR | LEVEL OF KNOWLEDGE |
|---|---|---|
| **A knowledge base for engineering** *Demonstrated competence in university-levelmathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.* | Knowledge-base for specific engineering field | ADVANCED |
| **Problem analysis** *An ability to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex engineering problems to reach substantiated conclusions.* | Problem identification and formulation | ADVANCED |
| | Modelling | ADVANCED |
| | Analysis (uncertainty and incomplete knowledge) | ADVANCED |
| **Design** *An ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, and economic, environmental, cultural and societal considerations*. | Idea generation and selection | ADVANCED |
| | Detailed design | ADVANCED |
| | Validation and implementation | ADVANCED |
| **Impact of engineering on society and the environment** *An ability to analyze social and environmental aspects of engineering activities. Such abilities include an understanding of the interactions that engineering has with the economic, social, health, safety, legal and cultural aspects of society.* | Awareness of society and environment impact | INTRODUCTORY |
| **Life-long learning** *An ability to identify and to address their own educational needs in a changing world in ways sufficient to maintain their competence and to allow them to contribute to the advancement of knowledge.* | Continuous improvement and self-learning | ADVANCED |

**Course Learning Outcomes (CLOs):**

Upon successful completion of MECH451, the students will be able to:

| | |
|---|---|
| - Analyze, and critically compare and evaluate selected sustainability concepts and strategies addressing renewable energy systems. | **A knowledge base for engineering**/ Knowledge base for specific engineering field<br>**Problem analysis**/ Problem identification and formulation<br>**Problem analysis**/ Modelling |
| - Characterize the global energy system and analyze the structure and constraints of today's energy system,<br>- Explain the availability and connection between solar and wind energy,<br>- Identify the problems and challenges of energy supply due to fluctuating energy resources with varying and seasonal load profiles | **A knowledge base for engineering/** Knowledge-base for specific engineering field<br>**Problem analysis/** Problem identification andformulation<br>**Problem analysis**/ Modelling<br>**Problem analysis**/ Analysis (uncertainty and incomplete knowledge) |
| - Understand, describe and compare major technologies for solar energy use: solar thermal and photovoltaic systems<br>- Analyze various system components and their interconnections within a solar energy system.<br>- Critically evaluate and describe basic characteristics and functioning of wind energy converters<br>- Understand the physical principal of wind energy conversion | **A knowledge base for engineering**/ Knowledge base for specific engineering field<br>**Problem analysis**/ Problem identification and formulation<br>**Problem analysis**/ Modelling |
| - Critically evaluate and compare two Renewable Energy conversion processes which allow continuous power supply on demand (hydropower and biomass energy) | **A knowledge base for engineering/** Knowledge-base for specific engineering field<br>**Problem analysis/** Problem identification andformulation<br>**Problem analysis/** Modelling<br>**Problem analysis/** Analysis (uncertainty andincomplete knowledge) |
| - Merge the acquired scientific knowledge on different Renewable Energy technologies and the concepts and methodologies they have gained in the different related disciplines, and they transfer their competences to solve a real-life project. | **Problem analysis**/ Problem identification and formulation<br>**Problem analysis**/ Modelling<br>**Problem analysis/** Analysis (uncertainty and incomplete knowledge)<br>**Design**/ Idea generation and selection<br>**Design/** Detailed design<br>**Design**/ Validation and implementation |
| - Implement an energy solution considering its impact on society and environment | **Impact of engineering on society and the environment**/Awareness of society and environment impact |
| - Identify missing knowledge and learn about the further application and design renewable energy systems. | **Life-long learning**/ Continuous improvement and self-learning |

**Health and Safety Guidelines**

All health and safety rules specific to this course can be found in the lab manual. General health and safety instructions and available health and safety trainings are discussed at:
Safety Programs - Concordia University

**ON CAMPUS RESOURCES**

Student may find the full list of available resources at:

- Important Services & Resources - Concordia University
- A-Z Student Services - Concordia University

While they are included in above mentioned two links, following list includes frequently searched services and resources available for students.

1. Academic Resources - Concordia University
    a. Academic integrity - Concordia University
    b. Undergraduate Calendar - Concordia University
    c. Graduate Calendar - Concordia University (For Graduate Classes)
    d. Academic dates – Undergraduate - Concordia University
    e. Important dates – Graduate - Concordia University (For Graduate Classes)
    f. Learning services - Concordia University
    g. Advocacy - Concordia University
2. Health & Wellness - Concordia University
    a. Access Centre for Students with Disabilities - Concordia University
    b. Mental health - Concordia University
3. Safety & security - Concordia University
    a. Security services - Concordia University
    b. Environmental Health and Safety - Concordia University
    c. Safety Training - Concordia University
4. International students - Concordia University